



Paleontological Resource Inventory and Monitoring

SOUTHERN PLAINS NETWORK



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On the Cover:

A partial skull of a Pleistocene Bison with both horn cores nearly complete to the tips from a locality in Lake Meredith National Recreation Area. The skull is identified as a female distinguished by relatively slender horn cores that curve almost imperceptively upward. This rare specimen is on display at the Panhandle Plains Museum near Amarillo, Texas, and perhaps represents the largest female *Bison latifrons* remains known. For more information on the fossils of Lake Meredith National Recreation Area see pages 16-18.

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INTRODUCTION

Paleontological resources are the remains of past life preserved in a geologic context. These fossils are non-renewable resources that possess scientific and educational values.

Establishment of baseline paleontological resource data is essential for the appropriate management of fossils found within National Park Service areas. Although over 160 National Park Service areas have been identified with paleontological resources, only a small percentage of these parks have adequate baseline paleontological resource data.

In conjunction with the National Park Service Geologic Resources Division and Inventory and Monitoring Networks, comprehensive paleontological resource inventories have been initiated in dozens of parks servicewide. This report represents paleontological resource inventory and monitoring data compiled for the parks within the Southern Plains Network.

The Southern Plains Network is comprised of 11 National Park Service areas: Alibates Flint Quarries National Monument, Bent's Old Fort National Historic Site, Capulin Volcano National Monument, Chickasaw National Recreation Area, Fort Larned National Historic Site, Fort Union National Monument, Lake Meredith National Recreation Area, Lyndon B. Johnson National Historical Park, Pecos National Historical Park, Sand Creek Massacre National Historic Site, and Washita Battlefield National Historic Site. These parks are located in southeastern Colorado, Kansas, New Mexico, Oklahoma, and Texas. The Southern Plains Network preserves temperate, subtropical steppe, and prairie ecoregions. These significant environments are embedded in agricultural landscapes.

Fossiliferous geologic units range from the Cambrian (around 515 million years ago) to the Quaternary. Significant fossils of invertebrates, vertebrates, plants, and traces have been found in some of the parks, and the potential to discover new localities is great. The confirmed paleontological resources found within park boundaries include petrified wood, plant material, mollusks, mammoth, bison, and fossil burrows.

Resources particularly worth noting include a partial skull of a Pleistocene *Bison* with both horn cores nearly complete to the tips was collected from a locality in Lake Meredith National Recreation Area. The skull is identified as a female distinguished by relatively slender horn cores that curve almost imperceptively upward. This rare specimen is on display at the Panhandle Plains Museum near Amarillo, Texas, and perhaps represents the largest female *Bison latifrons* remains known. Additionally, the abundance and variety of the fossil assemblages at Chickasaw National Recreation Area are extraordinary.

The Southern Plains Network is also unique for the first Oil and Gas Environmental Impact Statement (EIS) that considered paleontological resources (Santucci, 2000). The Oil and Gas EIS for Alibates Flint Quarries National Monument and Lake Meredith National Recreation Area contained a section that discussed paleontological resources as well as developed standard operating procedures for fossil resources.

The variety, abundance, and great potential for fossils in the Southern Plains Network dictates that these areas be included in the many paleontological resource gems within the National Park Service.

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ALIBATES FLINT QUARRIES NATIONAL MONUMENT

Alibates Flint Quarries National Monument (ALFL) was originally preserved in 1965. The agatized dolomite in the area was sought after for thousands of years to make projectiles and tools. ALFL preserves a unique blend of cultural and geological resources.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES:

The Alibates Dolomite is Permian in age and contains an abundance of flint (Horn, 1963). This flint was used by some of the earliest humans to make tools and points. The flint can often be found in alternating beds of gray and red (Horn, 1963). No fossils are found from these rocks at ALFL (P. Eubank, personal communication, 2003).

The oldest fossiliferous unit exposed in ALFL is the Miocene-Pliocene Ogallala Formation (approximately 12 to 5 million years ago). At least six documented fossil localities within the Ogallala Formation exist in ALFL and/or the neighboring park, Lake Meredith National Recreation Area (LAMR). Root casts, silicified grass anthoecia, endocarps of drupes of *Celtis* sp., gastropods, oysters, fishes, turtle remains, a mastodon tooth, insect burrows, and additional bone material were all discovered in this formation (Phillips, 2000; Hunt and Santucci, 2001).

The fossiliferous Pleistocene deposits at ALFL are composed of terrace gravels, fluvial sandstones and conglomerates, and alluvial sandstones and loess. There are several documented Pleistocene fossil localities within ALFL and/or LAMR. Remains of *Bison latifrons*, gastropods, and a rodent burrow were discovered at one site and reported by Anderson (1977). Another site produced mammoth remains, as well as petrified wood and shell fragments (Hunt and Santucci, 2001). In an ash deposit, dated to approximately 610,000 years ago, crayfish burrows and abundant plant material were found (Hunt and Santucci, 2001). Two significant fossil localities were found a few miles north of the town of Sanford, near the LAMR boundary. Pleistocene fossils discovered from these sites include fish, frog, snake, beaver, pocket gopher, muskrat, dog, fox, camel, deer, mammoth, and horse (Dalquest and Schultz, 1992).

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BENT'S OLD FORT NATIONAL HISTORIC SITE

Bent's Old Fort was established as a national historic site (BEOL) in 1960. During much of this fort's existence, it was the major permanent white settlement along the Santa Fe Trail between Missouri and Mexican settlements. Explorers, adventurers, and the military used this site as a convenient trading post and place of rest. The fort was abandoned in 1849 and later rebuilt in 1976.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES:

The oldest fossil-bearing unit exposed in BEOL is the Cretaceous Bridge Creek Member of the Greenhorn Limestone Formation. Although no paleontological resources have yet been reported from this formation within the park boundaries, there are various reports of fossils from this formation. Near the park boundaries (approximately 8 km northeast of La Junta), a collection of 28 fossil rudists (extinct bivalve) was made, and this fossil-bearing bed extends into the park (Cobban, et al., 1985). Additionally, foraminifera, ammonites, and fossil burrows have been found in the Greenhorn Limestone (Cobban and Scott, 1972; Hattin, 1971; Worstell, 1966).

Mammoth remains have been discovered in the Quaternary deposits at BEOL. Tusk fragments were found in a gravel bed by Jackson Moore, a NPS archeologist, between 1963 and 1966 (Moore, 1973). The park's museum also houses three additional tusk fragments identified by archeologist Jerry Dawson (Scott, et al., 2001). Unfortunately, these specimens do not have provenience information associated with them.

COOPERATIVE PROJECTS:

- Geologic and Paleontologic Scoping of Bent's Old Fort National Historic Site – National Park Service Geologic Resources Division (October 1998).

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CAPULIN VOLCANO NATIONAL MONUMENT

Capulin Volcano National Monument (CAVO) preserves 792 acres containing an inactive volcano with associated lava flows and other volcanic features. This geologically recent, cinder-cone-shaped, extinct volcano is now home to flourishing plant and animal communities. The park receives around 65,000 visitors annually.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES:

The geology exposed at CAVO is comprised of the Capulin Volcano cinder cone and four lava flows. These volcanic deposits cover the entire expanse of the park and continue outside the park boundaries. Outstanding preservation of these igneous features and processes is due largely to the relatively young age (between 62,000 to 56,000 years ago) and dry climate of the area (Kiver and Harris, 1999). Paleontological resources, however, have not been noted from these deposits and are likely not preserved. Apart from occasional tree molds, fossils are rarely found in igneous deposits.

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CHICKASAW NATIONAL RECREATION AREA

Chickasaw National Recreation Area (CHIC) was the first national park established in the state of Oklahoma. The park preserves lakes, streams, and springs, and therefore provides the opportunity for abundant water sports and activities. Not surprisingly, CHIC experiences some of the highest visitation in the service relative to its size.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES:

The oldest geologic formation at CHIC is the Middle Ordovician Bromide Formation of the Simpson Group, and contains many invertebrate fossils. Brachiopods, echinoderms, trilobites, pelycopods, bryozoans, graptolites, and ostracodes have all been discovered within the park. Many researchers have reported upon specific fauna from the Bromide Formation. Levinson (1961) discovered a new genera and species of ostracod from the Bromide Formation of Oklahoma. Branson (1966) reported on eight different species of the bivalve genus *Conocardium*, which are in the collections at the University of Oklahoma. A new bifoliate tubular bryozoan genera found in the Simpson Group of the Arbuckle Mountains was discussed by Farmer (1975). Thirty-one species of bryozoans from the Bromide Formation in Oklahoma were studied by Loeblich in 1942. Many Bromide Formation trilobite investigations have been conducted, including the genera *Calliops*, *Dolichoharpsi*, *Encrinuroides*, *Homotelus*, *Lonchodomas*, and *Pandaspinygia* (Esler, 1964; Frederickson, 1964; Sutherland and Amsden, 1959). Just south of CHIC's boundary and southeast of Sulphur, a new bryozoan reef was discovered in the Bromide Formation (Cuffey and Cuffey, 1994). Also outside the national recreation area boundary, the type locality for an echinoderm species exists (R. Burkhalter, personal communication, 2003).

The next fossiliferous unit is the Viola Group, which is Upper Ordovician in age. This unit is exposed in several areas of CHIC and contains deep-water fauna; *Cryolithus trilobites* (trilobite), and graptolites in particular. One incredibly well-preserved specimen of the trilobite, *Isotelus* was discovered from the Viola Limestone in Coal County, Oklahoma (Amsden and Ham, 1959). Convergence and other character traits of cryptolithinid trilobites within the Oklahoma biogeographic boundary were studied by Shaw (1991). Additionally, the type locality for a species of trilobite is found just outside the park boundaries in the Viola Group (R. Burkhalter, personal communication, 2003).

Although the Silurian time period (439 to 409 million years ago) is not well represented at CHIC, limited exposure of the Silurian Sylvan Shale can be found within the park boundaries. Fossil graptolites have been discovered from these deposits (W. Edgar, communication, unknown date).

The Devonian Hunton Group is represented at CHIC through the Chimneyhill Subgroup and the Haragan Formation. Although the Chimneyhill Subgroup has only produced a few fossils, including the less abundant bivalve genera of *Conocardium*, the Haragan Formation has proved to be very fossiliferous (Branson and Amsden, 1958). A highly productive locality in the Goddard Youth camp area has produced trilobites, brachiopods, corals, gastropods, and bivalves (R. Burkhalter, personal communication, 2003). Straight cephalopods (*Rhinoceras* sp.), gastroliths (stomach stones), goniatites (ammonites), and shark material have also been found from the Devonian strata (W. Edgar, communication, unknown date). Graptolites near Dougherty, Oklahoma, in the Haragan Formation were researched by Decker (1941). A new species of aulacopleuroidean trilobite was described from the Haragan Formation by Adrain and Kloc (1997).

The paleontology collections at CHIC contain additional fossils from outside the park. These fossils include collections made from other parts of Oklahoma, Illinois, Montana, Wyoming, and Germany. Additional invertebrate fauna and paleobotanical material are catalogued in the collection. The collections total almost 40 paleontological specimens.

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FORT LARNED NATIONAL HISTORIC SITE

Fort Larned National Historic Site (FOLS) was established in 1964 to preserve a military outpost developed in 1859 along the Santa Fe Trail. The fort served as a bureau of the Indian Agency, and later as a key military base during the Indian War of 1868-1869. Nine restored buildings are situated on the site.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES:

No paleontological resource discoveries have been made within the boundaries of FOLS. The sediments found at FOLS are all Post-Kansan deposits (younger than 0.39 million years old) (Ross, 1991). Quaternary alluvium exists throughout the park, which is composed of stream and flood deposits of silt and silty-clay. No bedrock is found within the park (Revello, 2003, personal communication). There are neighboring archeological sites that have been investigated; however, no paleontological resources were reported from these sites (Revello, 2003, personal communication). The potential to find fossils within the alluvium of the park does exist.

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FORT UNION NATIONAL MONUMENT

Fort Union National Monument (FOUN) was established in 1954 and preserves the remains of the Southwest's largest frontier fort. The fort played a pivotal role in the Indian Wars and the Confederate defeat at Glorieta Pass. Additionally, Santa Fe Trail ruts are preserved at the park.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES:

The primary geologic formation exposed at FOUN is the Upper Cretaceous Graneros Shale. This marine-deposited transgressive (sea level rising) unit has been dated using fossil oysters (*Ostrea beloiti*) (Kues and Lucas, 1987). The environment of the Graneros Shale ranges from offshore, low-energy waters of midshelf depth to moderately active waters below wave base (Kauffman et al., 1969). Although no fossil discoveries have been reported from within the boundaries of the park, paleontological resources have been found in other areas from this same formation within New Mexico and other surrounding states. Kauffman and others (1969) describe biostratigraphic zones in the Graneros Shale from the Raton Basin. The oldest to the youngest biostratigraphic zones are *Ostrea beloiti*, *Inoceramus bellvuensis*, *Calycoceras* sp., *Acanthoceras wintoni*, and *Ostrea noctuensis*. Additional fauna from the Graneros Shale include the following bivalves and gastropods: *Callistina lamarensis*, *Euomphalceras lonsdalei*, *Tarrantoceras stantoni*, *Johnsonites sulcatus*, *Exogyra columbella levis*, *Exogyra columbella columbella*, *Crassatellia excavata*, and *Turritella* cf. *thompsonina* (Kauffman, et al., 1969). Foraminifera from the Graneros Shale were studied by Eicher (1965) in Colorado, Kansas, Utah, and Wyoming. Most of the specimens found were arenaceous benthonic species, although some calcareous planktonic and rare calcareous benthonic species were also noted. Five new species and one new subspecies were discovered from Eicher's investigations; namely, *Trochamminoides apricarius*, *Haplophragmoides gilberti*, *Ammobaculites impexus*, *Ammobaculoides mosbyensis*, *Verneuilina alameda*, and *Trochammina rutherfordi mellariolum*.

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LAKE MEREDITH NATIONAL RECREATION AREA

Lake Meredith National Recreation Area (LAMR) lies on the High Plains of the Texas Panhandle and was originally preserved in 1965. Lake Meredith was created by the Sanford Dam on the Canadian River and provides the opportunity for boating, fishing, swimming, windsurfing, and other recreational activities.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES:

The oldest fossiliferous units exposed in LAMR are Triassic in age and are found in the Dockum Group (approximately 210 million years old), which is divided into the Tecovas and Trujillo formations. The Tecovas Formation is the thicker unit (60 m) and is composed of mudstones, fluvial sandstones, and conglomerates. The Trujillo Formation is only 13 meters thick and composed of fluvial sandstones with conglomerates and mudstones. The Dockum Group has produced some of the most significant Late Triassic vertebrate fossils in the world. The vertebrates include metoposaurs (giant amphibians), phytosaurs, aetosaurs, rauisuchians, sail-backed reptile (*Spinosuchus*), and the dinosaurs *Caseosaurus* and *Tecovasaurus* (Hunt and Santucci, 2001). Petrified wood and invertebrate fossils were reported by Murray (1986, and 1989). Additional plant fossils have been found in the Triassic rocks of the area, including rare palm-like remains and fossil logs (Hunt and Santucci, 2001; Wilson, 1988). Some fossils are known from within the park boundaries and the likelihood of finding further specimens from these units is great.

The Miocene-Pliocene Ogallala Formation (dating from approximately 12 to 5 million years old) is found within the park boundaries and is a highly fossiliferous geologic unit. At least six documented fossil localities within the Ogallala Formation exist in LAMR and/or the neighboring park, ALFL. Root casts, silicified grass anthoecia, endocarps of drupes of *Celtis* sp., gastropods, oysters, fishes, turtle remains, a mastodon tooth, insect burrows, and additional bone material were all discovered in this formation (Phillips, 2000; Hunt and Santucci, 2001).

The fossiliferous Pleistocene deposits at LAMR are composed of terrace gravels, fluvial sandstones and conglomerates, and alluvial sandstones and loess. There are several documented Pleistocene fossil localities within LAMR and/or ALFL. Remains of a *Bison latifrons*, gastropods, and a rodent burrow were discovered at one site and reported upon by Anderson (1977). Another site produced mammoth remains, as well as petrified wood and shell fragments (Hunt and Santucci, 2001). In an ash deposit, dated to approximately 610,000 years ago, crayfish burrows and abundant plant material were found (Hunt and Santucci, 2001). Two significant fossil localities were found a few miles north of the town of Sanford, near the LAMR boundary. Pleistocene fossils discovered from these sites include fish, frog, snake, beaver, pocket gopher, muskrat, dog, fox, camel, deer, mammoth, and horse (Dalquest and Schultz, 1992).

Holocene (less than 10,000 years old) deposits of alluvium, aeolian sand, and soils have produced some fossil material within LAMR. Many of these paleontological resources are associated with archeological sites and include fossil remains of fish, turtle, snake, crow, antelope, rabbit, badger, gopher, mole, squirrel, rat, and prairie dog (Hunt and Santucci, 2001). Additionally, a partial skull of a Pleistocene *Bison* with both horn cores nearly complete to the tips was collected. The skull is identified as a female distinguished by relatively slender horn cores that curve almost imperceptively upward. This rare specimen is on display at the Panhandle Plains Museum near Amarillo, Texas, and perhaps represents the largest female *Bison latifrons* remains known.

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LYNDON B. JOHNSON NATIONAL HISTORICAL PARK

Lyndon B. Johnson National Historical Park (LYJO) was established in 1969 to commemorate the 36th President of the United States. The park contains the reconstructed birthplace, boyhood home, ranch, grandparents' log cabin, and Johnson family cemetery. The park provides a unique glimpse into the life of one of America's most noteworthy presidents.

BASLINE PALEONTOLOGICAL RESOURCE INVENTORIES:

Although there are no reports of fossil discoveries within the LYJO boundaries, a wide variety of fossiliferous formations exist in the park. There is good potential that fossils do occur within the park, but have yet to be documented.

The oldest fossiliferous formation exposed in LYJO is the Cambrian Wilberns Formation. Decker (1945) reported upon graptolites from this formation. Miller (1976) and Miller and Stitt (1995) discuss various paraconodonts, conodonts, and trilobites from the Wilberns Formation. Fossil Hexactinellid sponge material was reported by Rigby (1975). The Wilberns formation is comprised of three fossiliferous members; Morgan Creek Limestone Member, Point Peak Member, and San Saba Member, which have all been investigated individually.

The Morgan Creek Limestone Member is composed of granular, glauconitic, thinly to thickly bedded limestone, which range in color from gray to red. Much of the limestone is composed of fossil fragments, and aphanitic to micro-granular stromatolites (algal mats) are common in the upper portion (Barnes, 1965b). Stromatolites, brachiopods, and trilobites are the most common specimens found in the Morgan Creek Limestone Member (Barnes, 1963; Barnes, 1965b; Barnes, 1966). Specifically, a variety of phosphatic and calcitic species of trilobites and brachiopods that have been found correspond to the following faunal zones: *Ptychaspis-Prosaukia*, *Conaspis*, *Elvinia*, and *Dunderbergia* (Barnes, 1963).

The Point Peak Member is characterized by greenish-gray, granular, silty, thinly bedded to massive limestone, and aphanitic stromatolite beds. The most abundant fossils are the stromatolitic bioherms and zones (Barnes, 1963; Barnes, 1965b; Barnes, 1967). Barnes (1966) reports that fossils are abundant in this member. More specifically, *Acrotreta*, *Billingsella*, and other brachiopods are known (Barnes, 1967).

The San Saba Member contains both fine-grained and massive coarse-grained dolomitic facies, as well as calcitic facies and chert beds. This member is not fossiliferous throughout all exposures, and the specimens are mostly found in dolomite and chert (Barnes, 1966). A few localities within the San Saba Member have produced many specimens, including brachiopods (*Finkelburgia* sp. and *Plectotrophia* cf. *bridgei* [Ulrich and Cooper]); gastropods (*Scaevogyra* cf. *swezeyi* [Whitfield], *Schizopea* cf. *elevate* [Ulrich and Bridge], *Dirhachopea* cf. *normalis* [Ulrich and Bridge], *Sinuopea* sp., and *Anconochilus barnesi* [Knight]); trilobites (*Stenopilus* sp. and *Plethometopus* sp.); bivalves (*Xenorthis* sp.); and monoplacophorans (*Hypseloconus* sp.) (Barnes, 1963).

The other fossiliferous unit within LYJO is the Cretaceous Shingle Hills Formation. This formation is composed of two geologic members: the Hensell Sand Member and the Glen Rose Limestone Member.

The Hensell Sand Member is composed of sand, silt, and clay, is predominantly red and gray, and contains conglomerate at the base. Paleontological resources are scarce in this member; however, some fossils have been identified. The specimens include bivalves (*Ostrea* sp., *Panope*? cf. *knowltoni*, *Cucullaea* sp., *Pecten* (*Chlamys*) *stantoni*) and gastropods (*Cassiope branneri* and *Nerinea* sp.) (Barnes, 1966).

The Glen Rose Limestone Member contains alternating beds of limestone, marl, and clay. The fossiliferous *Salenia texana* zone and *Corbula* bed have been identified in this member. Some of the beds in the Glen Rose Limestone Member are highly fossiliferous, producing genera of gastropods (*Nerinea*, *Tylostoma*, *Turritella*, *Trapezium*?, and *Lunatia*?); bivalves (*Gryphaea*, *Panope*?, *Tapes*, *Modiola*, *Anatina*, *Arctica*, *Cucullaea*, *Trigonia*, *Cardium*?, *Protocardia*, *Cyprimeria*, *Lima*, *Pecten*, *Cardita*, *Ostrea*, *Homomya*, *Exogyra*, *Astarte*, *Cuspidaria*, and *Anomia*); echinoids (*Enallaster*, *Porocystis*, and *Loriola*); and trace fossils (*Serpula*) (Barnes, 1965a and Barnes, 1966).

Quaternary alluvium is also exposed within the park. The alluvium is composed of gravel, sand, and silt from along stream bottoms. There have been no reports of fossils found within these deposits.

COOPERATIVE PROJECTS:

- Geologic and Paleontologic Scoping of Lyndon B. Johnson National Historical Park – National Park Service Geologic Resources Division (May 2003).
- Geologic Inventory of Lyndon B. Johnson National Historical Park – National Park Service Geologic Resources Division (2003, and is ongoing).

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PECOS NATIONAL HISTORICAL PARK

Pecos National Historical Park (PECO) was established in 1965 and preserves 12,000 years of human history. Pecos Pueblo and other American Indian structures, Spanish colonial missions, Mexican era homesteads, a section of the Santa Fe Trail, sites related to the Civil War Battle of Glorieta Pass, and a 20th century ranch are all preserved at PECO. This rich tapestry of history and heritage provides insights into the American past.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES:

Although no fossils have been discovered from within the boundaries at PECO, two geologic units are exposed at the park that have been reported with paleontological resources in other areas.

The oldest fossiliferous formation exposed at PECO is the Upper Pennsylvanian to Lower Permian Sangre de Cristo Formation. This approximately 500-foot-thick unit is composed of conglomerate, buff and red sandstone, red siltstone, red and greenish-gray shale, and gray limestone. Vaughn (1969 and 1972) reported upon multiple fossil vertebrates from the Sangre de Cristo Formation in Colorado, most notably the microsauro *Trihecaton howardinus*. Other specimens include palaeoniscoid fishes, labyrinthodont amphibians, aistopod amphibian, diadectid cotylosaur, and various pelycosaur.

The other fossiliferous formation exposed at PECO is the Upper Pennsylvanian Upper Member of the Madera Formation. The strata are composed of gray limestone, red and greenish-gray shale, and brownish-red conglomeratic sandstone. Multiple reports of fossils from the Madera Formation suggest that there is a strong possibility of discovering specimens within PECO. Marine invertebrates were studied by Kues and others (1997) in Sandoval County. A well-preserved specimen of the large gastropod *Pharkidonotus megalis* was found in south-central New Mexico and reported by Kues (1987). Shrimp were also discovered from the Madera Formation in the Manzanita Mountains of New Mexico (Schram and Schram, 1979). Kues and Kietzke (1981) report a large assemblage of the eurypterid *Adelophthalmus luceroensis* from Valencia County, in central New Mexico. A sequence of fusulinids were outlined in the Madera Formation from Huerfano Park, Colorado, that helped to disclose the depositional environment of marine transgression (Tischler, 1963). Fossil plants, insects, conchostracans, brachiopods, and disarticulated fishes from Bernalillo County were reported by Huber and others (1989a). A diverse vertebrate assemblage from the Madera Formation of New Mexico was presented by Rowland and others (1997). Additional vertebrates are reported from the Madera Formation by Berman (1973), and Cook and Lucas (1998). Berman described a new genus and species of a trimerorhachid labyrinthodont amphibian (*Lafonius lehmani*) from the Manzano Mountains, in north-central New Mexico. Cook and Lucas report upon a locality in central New Mexico that includes various fragments of pelycosaurian reptiles, a diadectomorph reptile, an embolomorph amphibian, and a hybodont shark.

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DATA SETS:

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SAND CREEK MASSACRE NATIONAL HISTORIC SITE

Sand Creek Massacre National Historic Site (SAND) was authorized in 2000, though it is not currently established. This park will preserve the site of the U.S. Army's massacre of 150 Cheyenne and Arapaho people in southeastern Colorado. These actions were later condemned, following three federal investigations. The National Park Service is in the process of acquiring enough land to sufficiently preserve, commemorate, and interpret the massacre.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES:

There have been no documented fossil discoveries at SAND. The geology along the southeasterly-trending valley at the site is primarily composed of unconsolidated, Quaternary, wind-derived sand deposits (National Park Service, 2000). These sands overlay Pleistocene sands, silts, and gravels (Sharps, 1976). Quaternary dune sand and valley silt and sand deposits are found in the other areas of the park. A member of the fossiliferous Niobrara Formation lies 50 to 70 feet below these Quaternary deposits, but no hard strata is exposed within the park (Sharps, 1976). Although no fossils are known from this area, there is still the possibility of new discoveries within the Quaternary deposits. Additionally, paleontological resources may be found in association with archeological resources. This association may represent instances where fossils were found in the area or brought from other regions and left at the site.

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WASHITA BATTLEFIELD NATIONAL HISTORIC SITE

Washita Battlefield National Historic Site (WABA) was established in 1996 and preserves the site of an 1868 battle during which the U. S. Cavalry destroyed a Southern Cheyenne Village. This controversial event has been considered both a battle and a massacre.

BASELINE PALEONTOLOGICAL RESOURCE INVENTORIES:

The only formation exposed within the boundaries of WABA is the Cloud Chief Formation. This stratigraphic unit is Permian in age, and was deposited approximately 250 million years ago. The Cloud Chief Formation is composed primarily of redbeds of sandstone, siltstone, and shale. Additionally, this formation contains some impressive white gypsum beds. No fossils have been found within WABA, although a few were discovered in this formation from just east of the park boundary by Janet Brown, GeoScientists-in-the-Parks participant. The fossils include cup corals, coiled cephalopods, and trace fossils of worm trails (Brown, 2001). The Cloud Chief Formation has not been known to produce many fossils due to the poor preservation conditions occurring in the paleoenvironment.

The Ogallala Formation (12 to 5 million years old) is exposed outside the park boundaries, and can be seen in the neighboring Antelope Hills and Twin Hills. This well-known fossiliferous formation contains a diverse fossil mammal fauna, including ancestors of antelope, camel, horse, elephant, leopard, and llama.

COOPERATIVE PROJECTS:

- Geology and paleontology data compilation of Washita Battlefield National Historic Site – Janet Brown, GeoScientists-in-the-Parks Intern (2001)

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DATA SETS:

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XXX Washita Battlefield National Historic Site Paleontological Archives. 5/1985 – present. (hard copy data; reports; electronic data; photographs; maps; publications). Originated by Santucci, Vincent; status: Active.

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XXX Geology and Paleontology of Washita Battlefield National Historic Site. 2001. (hard copy data; locality data; field maps; site bulletin; photographs). Originated by Brown, Janet; status: Inactive.

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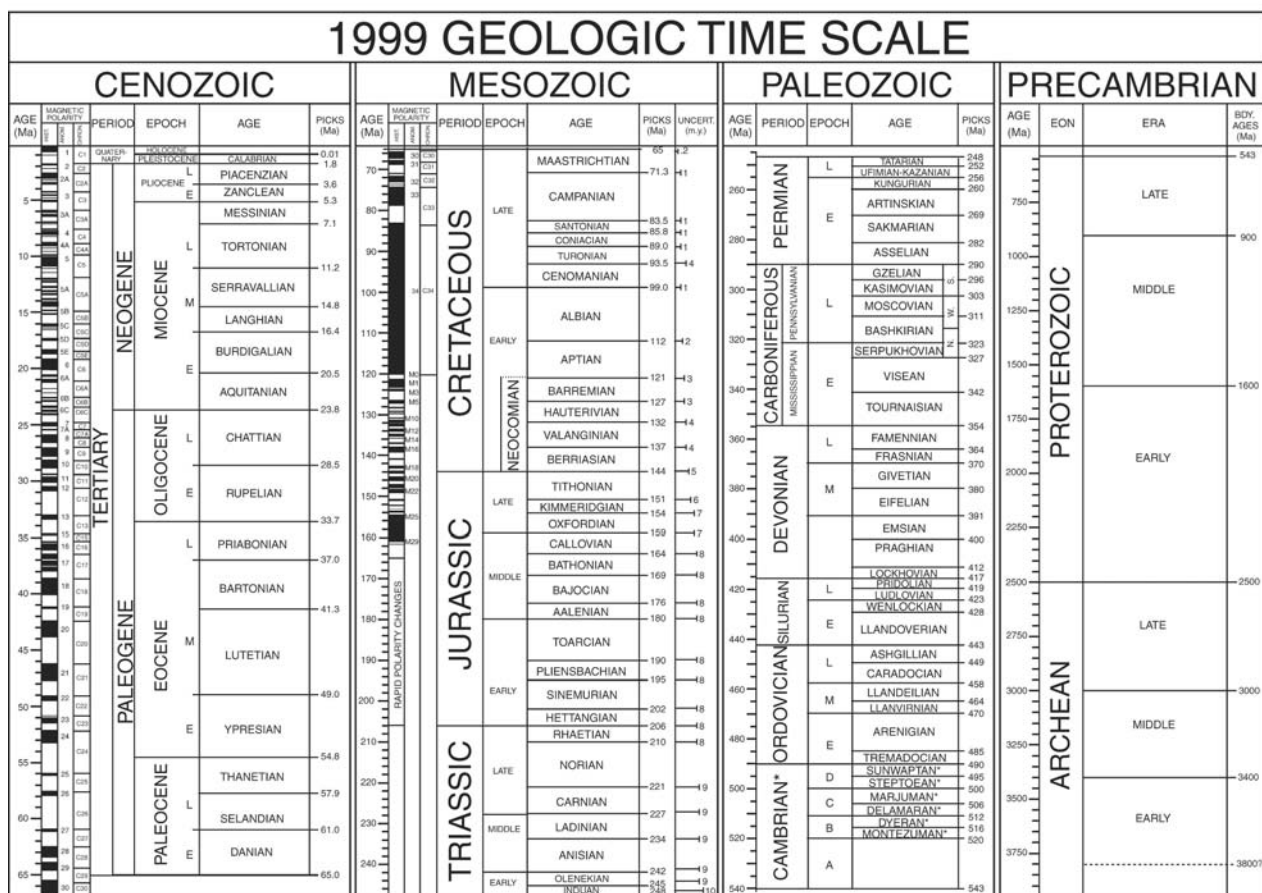
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APPENDIX A: GEOLOGIC TIME SCALE



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*International ages have not been established. These are regional (Laurentian) only. Boundary Picks were based on dating techniques and fossil records as of 1999. Paleomagnetic attributions have errors. Please ignore the paleomagnetic scale.

Sources for nomenclature and ages: Primarily from Gradstein, F., and Ogg, J., 1996, *Episodes*, v. 19, nos. 1 & 2; Gradstein, F., et al., 1995, *SEPM Special Pub. 54*, p. 95-128; Berggren, W. A., et al., 1995, *SEPM Special Pub. 54*, p. 129-212; Cambrian and basal Ordovician ages adapted from Landing, E., 1998, *Canadian Journal of Earth Sciences*, v. 35, p. 329-338; and Davidek, K., et al., 1998, *Geological Magazine*, v. 135, p. 305-309. Cambrian age names from Palmer, A. R., 1998, *Canadian Journal of Earth Sciences*, v. 35, p. 323-328.